## WHAT IS CLAIMED IS:

1        1. A pump comprising:

2        a pump body for at least partially defining a pumping chamber and an inlet and

3    an outlet which communicate with the pumping chamber;

4        a piezoelectric actuator situated in the pump body and responsive to a drive

5    signal for pumping fluid between the inlet and outlet; and

6        a drive circuit which produces the drive signal so that the drive signal has a

7    waveform of a predetermined waveform shape, the drive circuit including a memory,

8    the memory having stored therein waveform shape data which is utilized by the drive

9    circuit in producing the drive signal.


1        2. The apparatus of claim 1, wherein the drive circuit includes a controller

2    which generates a digital signal using the waveform shape data stored in the memory.


1        3. The apparatus of claim 1, wherein the drive circuit utilizes the waveform

2    shape data so that for each of plural points comprising a period of the waveform the

3    drive signal has an appropriate amplitude for the predetermined waveform shape.


1        4. The apparatus of claim 3, wherein the waveform shape data is in paired

2    relation to the plural points comprising the period of the waveform.


1        5. The apparatus of claim 3, wherein the waveform shape data comprises

2    amplitude values which are in paired relation to the plural points comprising the period

3    of the waveform.


1        6. The apparatus of claim 3, wherein the waveform shape data comprises pulse

2    width modulation values which are in paired relation to the plural points comprising the

3    period of the waveform.


1        7. The apparatus of claim 1, wherein the waveform shape data has been

2    prepared to optimize an operational parameter of the pump.

1   8. The apparatus of claim 7, wherein the operational parameter which is
2   optimized by the waveform shape data is one of: fluid flow in the pump; pressure in
3   the pump; acceleration; noiselessness; acceleration; and noiselessness.

1   9. The apparatus of claim 7, the waveform shape data has been prepared to
2   optimize plural operational parameters of the pump.

1   10. The apparatus of claim 1, wherein the waveform shape data has been
2   prepared by solving a waveform equation, the waveform equation having coefficients
3   determined to optimize at least one operational parameter of the pump.

1   11. The apparatus of claim 1, wherein the waveform shape data has been
2   prepared by solving a waveform equation, the waveform equation having coefficients
3   determined to optimize at least one operational parameter of the pump.

1   12. The apparatus of claim 10, wherein a number of coefficients determined for
2   the waveform equation depends on a number of harmonics of the waveform that are
3   within a bandwidth of the pump.

1   13. A drive circuit which produces a drive signal for a device having a
2   piezoelectric actuator, the drive circuit being arranged to produce the drive signal so
3   that the drive signal has a waveform of a predetermined waveform shape, the drive
4   circuit including a memory, the memory having stored therein waveform shape data
5   which is utilized by the drive circuit in producing the drive signal.

1   14. The apparatus of claim 13, wherein the drive circuit includes a controller
2   which generates a digital signal using the waveform shape data stored in the memory.

1   15. The apparatus of claim 13, wherein the drive circuit utilizes the waveform
2   shape data so that for each of plural points comprising a period of the waveform the
3   drive signal has an appropriate amplitude for the predetermined waveform shape.

1   16. The apparatus of claim 15, wherein the waveform shape data is in paired
2   relation to the plural points comprising the period of the waveform.

1    17.  The apparatus of claim 15, wherein the waveform shape data comprises
2    amplitude values which are in paired relation to the plural points comprising the period
3    of the waveform.

1    18.  The apparatus of claim 15, wherein the waveform shape data comprises
2    pulse width modulation values which are in paired relation to the plural points
3    comprising the period of the waveform.

1    19.  The apparatus of claim 13, wherein the waveform shape data has been
2    prepared to optimize an operational parameter of the device.

1    20.  The apparatus of claim 19, wherein the device is a pump, and wherein the
2    operational parameter which is optimized by the waveform shape data is one of: fluid
3    flow in the pump;  pressure in the pump; acceleration; and noiselessness.

1    21.  The apparatus of claim 19, the waveform shape data has been prepared to
2    optimize plural operational parameters of the device.

1    22.  The apparatus of claim 13, wherein the waveform shape data has been
2    prepared by solving a waveform equation, the waveform equation having coefficients
3    determined to optimize at least one operational parameter of the device.

1    23.  The apparatus of claim 13, wherein the waveform shape data has been
2    prepared by solving a waveform equation, the waveform equation having coefficients
3    determined to optimize at least one operational parameter of the device.

1    24.  The apparatus of claim 23, wherein a number of coefficients determined for
2    the waveform equation depends on a number of harmonics of the waveform that are
3    within a bandwidth of the device.

1    25.  The apparatus of claim 13, wherein the device is a pump.

1    26.  A memory for use by a drive circuit which produces a drive signal for a
2    device having a piezoelectric actuator, the memory having stored therein waveform
3    shape data which is utilized by the drive circuit in producing the drive signal.

1     27.  The apparatus of claim 26, wherein the waveform shape data is in paired
2     relation to plural points comprising the period of the waveform.

1     28.  The apparatus of claim 26, wherein the drive circuit utilizes the waveform
2     shape data so that for each of plural points comprising a period of the waveform the
3     drive signal has an appropriate amplitude for the predetermined waveform shape.

1     29.  The apparatus of claim 26, wherein the waveform shape data is in paired
2     relation to plural points comprising the period of the waveform.

1     30.  The apparatus of claim 26, wherein the waveform shape data comprises
2     amplitude values which are in paired relation to plural points comprising the period of
3     the waveform.

1     31.  The apparatus of claim 26, wherein the waveform shape data comprises
2     pulse width modulation values which are in paired relation to plural points comprising
3     the period of the waveform.

1     32.  The apparatus of claim 26, wherein the device is a pump.

1     33.  The apparatus of claim 32, wherein the waveform shape data has been
2     prepared to optimize an operational parameter of the pump.

1     34.  The apparatus of claim 33, wherein the operational parameter which is
2     optimized by the waveform shape data is one of: fluid flow in the pump; pressure in the
3     pump; acceleration; and, noiselessness.

1     35.  The apparatus of claim 33, the waveform shape data has been prepared to
2     optimize plural operational parameters of the pump.

1     36.  The apparatus of claim 26, wherein the waveform shape data has been
2     prepared by solving a waveform equation, the waveform equation having coefficients
3     determined to optimize at least one operational parameter of the device.

1    37.  The apparatus of claim 36, wherein the waveform shape data has been

2    prepared by solving a waveform equation, the waveform equation having coefficients

3    determined to optimize at least one operational parameter of the device.


1    38.  The apparatus of claim 36, wherein a number of coefficients determined for

2    the waveform equation depends on a number of harmonics of the waveform that are

3    within a bandwidth of the device.


1    39.  A method of operating a device having a piezoelectric actuator situated in a

2    pump body, the piezoelectric actuator being responsive to a drive signal, the method

3    comprising:

4         using waveform shape data stored in a memory to produce the drive signal so

5    that the drive signal has a waveform of a predetermined waveform shape;

6         applying the drive signal to the piezoelectric actuator.


1    40.  The method of claim 39, further comprising using the waveform shape data

2    to produce the drive signal so that for each of plural points comprising a period of the

3    waveform the drive signal has an appropriate amplitude for the predetermined

4    waveform shape.


1    41.  The method of claim 40, further comprising formatting the waveform shape

2    data in paired relation to the plural points comprising the period of the waveform.


1    42.  The method of claim 40, wherein the waveform shape data comprises

2    amplitude values, and further comprising formatting the waveform shape data in paired

3    relation to the plural points comprising the period of the waveform.


1    43.  The method of claim 40, wherein the waveform shape data comprises pulse

2    width modulation values, and  further comprising formatting the waveform shape data

3    in paired relation to the plural points comprising the period of the waveform.


1    44.  The method of claim 39, wherein the waveform shape data has been

2    prepared to optimize an operational parameter of the device.

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1    45.  The method of claim 39, wherein the device is a pump and the piezoelectric
2    actuator is responsive to the drive signal for pumping fluid between an inlet and an
3    outlet of a pump body.

1    46.  The method of claim 45, wherein the operational parameter which is
2    optimized by the waveform shape data is one of: fluid flow in the pump;  pressure in
3    the pump; acceleration; and, noiselessness.

1    47.  The method of claim 45, the waveform shape data has been prepared to
2    optimize plural operational parameters of the pump.

1    48.  The method of claim 39, wherein the waveform shape data has been
2    prepared by solving a waveform equation, the waveform equation having coefficients
3    determined to optimize at least one operational parameter of the device.

1    49.  The method of claim 39, wherein the waveform shape data has been
2    prepared by solving a waveform equation, the waveform equation having coefficients
3    determined to optimize at least one operational parameter of the device.

1    50.  The method of claim 49, wherein a number of coefficients determined for
2    the waveform equation depends on a number of harmonics of the waveform that are
3    within a bandwidth of the device.

1    51.  A method of preparing waveform shape data for use by a target drive circuit
2    of a device which comprises a piezoelectric actuator which receives a drive signal
3    generated by the target drive circuit, the method comprising:
4        generating a drive signal to apply to an operational piezoelectric actuator in an
5    operational device;
6        obtaining a feedback signal from the pump in accordance with an operational
7    parameter of the device;
8        using the feedback signal to determine coefficients of a waveform equation;
9        solving the waveform equation to obtain waveform shape data;
10        storing the waveform shape data in a memory.

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1     52. The method of claim 51, further comprising installing the memory in the
2    target drive circuit.

1     53. The method of claim 51, further comprising reading out the waveform shape
2    data from the memory and storing the waveform shape data in another memory in the
3    target drive circuit.

1     54. The method of claim 51, further comprising storing the waveform shape
2    data in a processor.

1     55. The method of claim 51, further comprising formatting the waveform shape
2    data in the memory in paired relation to plural points comprising the period of the
3    waveform.

1     56. The method of claim 51, wherein the waveform shape data comprises
2    amplitude values, and further comprising formatting the waveform shape data in the
3    memory in paired relation to plural points comprising the period of the waveform.

1     57. The method of claim 51, wherein the waveform shape data comprises pulse
2    width modulation values, and further comprising formatting the waveform shape data in
3    the memory in paired relation to plural points comprising the period of the waveform.

1     58. The method of claim 51, further comprising using the feedback signal to
2    determine coefficients of a waveform equation that optimize performance in terms of
3    the operational parameter.

1     59. The method of claim 58, wherein the device is a pump and the piezoelectric
2    actuator is responsive to the drive signal for pumping fluid between an inlet and an
3    outlet of a pump body.

1     60. The method of claim 59, wherein the operational parameter which is
2    optimized by the waveform shape data is one of: fluid flow in the pump; pressure in
3    the pump; acceleration; and noiselessness.

1     61. The method of claim 59, further comprising:

2        obtaining plural feedback signals from the pump in accordance with

3    corresponding plural operational parameters of the pump;

4        using the plural feedback signals to determine coefficients of a waveform

5    equation.


1        62. The method of claim 51, further comprising determining a number of

2    coefficients for the waveform equation in dependency on a number of harmonics of the

3    waveform that are within a bandwidth of the device.

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